

ENVIRONMENTAL SAFETY

UDC 666.1:662.6:504.2

ENVIRONMENTAL SAFETY IN MELTING GLASS USING DIFFERENT TYPES OF FUEL

S. I. Alimova¹ and M. V. Shapilova¹

Translated from Steklo i Keramika, No. 8, pp. 44–46, August, 2000.

Data on studying toxic emissions during container-glass melting based on various types of fuel are provided. It is demonstrated that emissions decrease when natural gas is used as the fuel.

The main atmospheric pollutants in glass production are material-processing lines and glass-melting furnaces. Waste on material preparation lines is characterized by high dustiness and outbursts of material during pneumotransportation. The pollutants from glass-melting furnaces, in addition to dust, contain gaseous products, including nitric oxides, which appear in the processes of high-temperature fuel combustion and decomposition of nitrogen-bearing materials, and sulfuric oxides generated by combustion of sulfur-containing fuel and by sulfates contained in the glass batch. The solid waste fraction in the emissions from a glass-melting furnace consists of highly disperse alkali and alkali-earth aerosols, and the waste from crystal glass melting contains lead-bearing aerosols.

¹ Research and Development Institute of Glass, Moscow, Russia.

TABLE 1

Contaminant	Aggregate state	Danger grade	Maximum permissible concentration, mg/m ³	
			max. one-time	average per day
Inorganic dust containing silicon dioxide in the amount of, %:				
< 20	Aerosol	3	0.5	0.15
> 70	The same	3	0.15	0.1
20–70	"	3	0.3	0.1
Nitric dioxide	Gas	2	0.085	0.04
Sulfurous anhydride	The same	3	0.5	0.05
Arsenic and its inorganic compounds	Aerosol, gas	2	—	0.003
Selenium dioxide (converted to selenium)	The same	1	0.0001	0.00005
Lead and its inorganic compounds	Aerosol	1	0.001	0.0003
Suspended matter	The same	3	0.5	0.15

The content of the gas-dust emissions from glass-melting furnaces is determined by a number of factors. Thus, the qualitative composition of emissions is characterized by the materials used in the glass batch and the fuel composition; the quantitative composition is determined by the furnace type and output, the share of cullet introduced in melting, and the combusted-fuel consumption.

Various measures can be adopted to reduce the outbursts of contaminants. Such measures for the material preparation sites include two-stage and three-stage purification of dust emissions using cyclones in the first stage and tissue filters in the second stage; for glass-melting furnaces these measures include batch granulation, electric melting of glass, an increase in the share of cullet introduced into the batch, and replacement of materials that on decomposition produce chemical agents classified as danger grades 1 and 2 [1]. Such chemicals include selenium, lead, arsenic, nitrogen, and sulfur compounds, silicon-containing dust, and suspended agents. Table 1 lists the danger grades and the maximum permissible concentrations for the contaminants released in the production of various types of glasses [2].

In the last decade, furnaces at several glass factories in Vladimir Region were converted to gas fuel. This had a positive effect on environmental safety. Until recently, Velikodvorskii Glass Factory and Krasnyi Oktyabr' JSC, which produce glass containers, were using mazut and furnace fuel in glass production. The present paper contains data obtained in a comparative study of dangerous atmo-

TABLE 2

Tank furnace*	Output, tons/day	Cullet content, %	Fuel	Liquid fuel characteristics		
				ash content, %	sulfur content, %	least combustion heat, mJ/kg
Velikodvorskii Glass Factory JSC	100	35	Mazut M-100	0.028	2.3	41.5
Krasnyi Oktyabr' JSC	33	40	Furnace fuel	0.020	0.5	42.7

* Recuperative continuous tank furnaces for clear container glass with transverse (Velikodvorskii Glass Factory JSC) and horse-shoe-shaped (Krasnyi Oktyabr' JSC) direction of flame.

TABLE 3

Tank furnace	Batch composition, kg per 100 kg glass							
	sand	soda	sodium sulfate	soda-sulfate mixture	dolomite	feldspar	alumina	carbon
Velikodvorskii Glass Factory JSC operating:								
on mazut	62.78	18.60	3.70	—	23.80	13.49	—	0.32
on gas	72.46	21.02	—	4.69	—	—	1.31	0.32
Krasnyi Oktyabr' JSC, furnace fuel	63.16	21.05	—	12.03	21.05	14.02	—	0.61

TABLE 4

Tank furnace	Sampling site	Temperature, °C	Cross-sectional area, m ²	Gas flow rate, m/sec	Fuel con- sumption, m ³ /h	Waste gas volume	
						nm ³ /h	nm ³ /sec
Velikodvorskii Glass Factory JSC	Smoke chimney, when operating:						
	on mazut	260	2.01	2.64	1100	19,080	5.3
Krasnyi Oktyabr' JSC	on gas	290	2.01	2.58	1257	18,720	5.2
	Smoke flue before the chimney, when operating:						
	on furnace fuel	120	1.78	2.36	450	15,120	4.2
	on gas	340	1.78	1.85	500	11,880	3.3

spheric emissions for furnaces operating on high-sulfur liquid fuel and on natural gas (Tables 2 and 3).

Samples of waste gases and dust particles were taken in the smoke chimney and in smoke flues before the chimney. The gaseous-fraction composition was determined on an IMR 2500-P computerized gas analyzer (Germany) using detailed chemical semi-microanalytical methods developed by the Research and Development Institute of Glass and approved by the Atmosfera Research Institute and the Ministry for Environmental Protection of the Russian Federation [3]. During sampling, the temperature, air excess coefficient, and heat loss via the smoke tract were monitored.

The samples were taken using the external filtration method by means of AFA-KhA and AFA-VP high-dispersion aerosol filters, isokinetically with respect to the waste-gas flow. The filters were subsequently analyzed using the gravimetric method.

Before determining the dustiness of the gas-air mixture, aerodynamic parameters of the emissions were studied. The dynamic and static pressure developed inside the furnace

chimney and smoke flues were measured using an MMN-240 micromanometer. The measurement results and the waste-gas flow rates are given in Table 4, and the rates and the overall values of contaminant emissions are presented in Table 5.

The results of the studies performed demonstrated that sulfurous anhydride emissions from the Velikodvorskii Glass Factory furnace decreased from 87 to 14 tons per year, and from the Krasnyi Oktyabr' furnace from 13 to 3 tons per year. This reduction (by a factor of 6 and 4, respectively) is due to the absence of sulfurous anhydride emissions in the fuel component of the waste, and its presence is caused by the sulfates used in the glass batch.

The replacement of furnace fuel by gas had an effect on the dust emissions as well, which decreased from 72 to 41 tons per year at the first factory and from 57 to 44 tons per year at the second factory, i.e., by a factor of 1.8 and 1.3. The decrease in the waste-gas dust content can be attributed as well to the decreased amount of sulfurous anhydride in the emissions. Sulfurous anhydride is bound with alkali oxide aerosols and forms sulfate-containing compounds, which are

TABLE 5

Tank furnace	Contaminant	Emission of contaminant when operating						Change in annual emissions, times	
		on liquid fuel			on natural gas				
		mg/m ³	g/sec	tons/year	mg/m ³	g/sec	tons/year		
Velikodvorskii Glass Factory JSC	Suspended matter	420.20	2.27	71.59	248.1	1.29	40.66	- 1.8	
	Nitric dioxide	438.50	2.32	73.16	589.3	3.06	96.50	+ 1.3	
	Sulfurous anhydride	521.30	2.76	87.14	84.0	0.44	13.88	- 6.3	
Krasnyi Oktyabr' JSC	Suspended matter	433.30	1.82	57.40	418.8	1.38	43.52	- 1.3	
	Nitric dioxide	278.57	1.17	36.76	436.2	1.44	45.41	+ 1.3	
	Sulfurous anhydride	95.24	0.40	12.50	30.2	0.099	3.12	- 4.0	

* The sign “–” means decrease in emissions, the sign “+” means their increase.

precipitated as dust and constitute up to 90% the solid fraction in emissions.

It can be seen in Table 5 that when sulfur-containing liquid fuel is used, the concentration of nitric oxides is lower. This is accounted for by the fact that the more active sulfur that is present in the fuel combines with the oxygen that participates in the combustion reactions and produces sulfurous compounds. That is why the nitric oxide emissions are slightly higher in gas-heated furnaces.

On the whole, due to conversion of glass-melting production to gas fuel, the Velikodvorskii Glass Factory and the Krasnyi Oktyabr' JSC reduced their emissions by 81 and

15 tons per year, respectively, i.e., the emissions became 1.5 and 1.2 times lower.

REFERENCES

1. M. V. Shapilova and I. T. Timofeeva, *Protection of the Atmosphere in Glass Production* [in Russian], Legpromizdat, Moscow (1992).
2. *List and Codes of Atmospheric Pollutants* [in Russian], St. Petersburg (1998).
3. *List of Methods for Measurements of the Concentration of Contaminants in Industrial Emissions* [in Russian], St. Petersburg (1999).